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ABSTRACT

This paper reports on research related to computer programing in the secondary school mathematics curriculum. The first section gives the background and nature of the problem, explains the organization and limitations of the study, and defines the terms used. The second section presents an annotated bibliography, organized into four parts. The first part includes: (1) studies on computer literacy; (2) uses of computers in education; (3) content to be taught in the secondary mathematics curriculum; and (4) characteristics of student programmers. The second part concerns the effect of the computer on student attitudes. The effect of the computer on student mathematical achievement is the focus of the third part, and the final part involves gender differences and the computer. In the third section of the paper, a summary of the annotated reports is given, followed by conclusions and four recommendations. A 26-item bibliography of works cited concludes the paper. (MNS)

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Computer Programming in the Secondary Mathematics Curriculum

by

James E. Funk

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Computer Programming in the

Secondary Mathematics Curriculum

INTRODUCTION

Background, Statement of the Problem, and Organization of the Study

The introduction of computing technology into the schools has brought with it a myriad of related problems to be solved and issues to be resolved. Once the computer hardware is installed, the school system is obligated to put it to the best possible use. One of the most important uses of the computer in schools is the teaching of programming (Becker 32). Teaching computer programming is usually done in the mathematics department, probably because both disciplines require similar thinking (Hearne and Lasley 83). Since the mathematics curriculum must be modified to accommodate the teaching of computer programming, it is reasonable to study the effects of such a curriculum modification. This paper reports on research related to computer programming in the secondary mathematics curriculum.

The study is organized into four fundamental areas. The first area includes issues related to computer literacy, uses of computers in education, content to be taught in the secondary mathematics curriculum, and characteristics of student programmers. The second area is the effect the computer has upon student attitudes. The third area is the effect the computer has upon student mathematical achievement, and the last area involves gender differences and the computer. Most of the articles relate directly to computer programming in the secondary mathematics curriculum, but occasionally a more general article on computers appears which is still highly relevant to the subject at hand.

Definition of terms

BASIC- "Beginners All-Purpose Symbolic Instruction Code. A higher level conversational programming language in wide use. Incorporates simple English words and common mathematical symbols." (Watson 284)

computer literacy- "familiarity with various aspects of computer use, as well as the societal implications of such use." (Pogrow 217)

debug- "the process of locating and eliminating errors." (Watson 284)

hardware- "the equipment which makes up a computer system." (Watson 285)

language- "the method by which one communicates with the computer ...." (Watson 286)

Logo- "a programming language for children." (Pogrow 218)

log on- "getting on the computer and ready to work." (IUSB Computing Handbook 12)

PASCAL- "a relatively new high level language named in honor of the French mathematician." (Watson 286)

program- "a series of instructions to a computer...." (Watson 286)

software- "programs and necessary documentation which are needed to make a computer 'do its thing'." (Watson 287)

Limitations of the study

The major limitation of this study is the scarcity of research available which relates directly to computer programming in the secondary mathematics curriculum. Several very general conclusions were drawn when the weight of the evidence tilted to one side, but often fragments of information appeared with no duplication in any other study. In the latter case, caution must be used when reading the available data.

It should also be noted that some of the studies abstracted are dated. When technology evolves as fast as it has for implementing computers into education, research studies become outdated even sooner than usual. For this reason, caution should be used when reading the older research.

ANNOTATIONS

General observations about computers in schools

Literacy and uses

"Readers' Survey Results: What is Computer Literacy?" Classroom Computer Learning 6 March 1986: 53.

A poll was taken in November 1985 to find out how computers were being used in education. Approximately 70 percent of the respondents were classroom teachers. The remainder were district level computer coordinators, administrators, media specialists, and college professors. It was learned that programming was a central focus of computer literacy. For choice of language, BASIC was used most overall, but respondents wanted more LOGO in the elementary grades and more PASCAL in the high schools. Finally, educators felt that they should concentrate on teaching the use of "tool programs" (such as word processors and database programs) as well as use educational software more often.

Hansen, Thomas P., Daniel L. Klassen, Ronald E. Anderson, and David C. Johnson. "What Teachers Think Every High School Graduate Should Know About Computers." School Science and Mathematics 81 (1981): 467-72.

Hansen et al. reported on a study conducted by the Special Projects Division of the Minnesota Educational Computing Consortium. This group tried to measure secondary school teachers' opinions of what every high school graduate should know about computers as well as how they are used in the classroom. The teachers generally agreed that every secondary student should have some minimal understanding of computers. Most of the teachers also agreed that every secondary school student should learn about the role that computers play in our society. There was far less support among the teachers for the proposition that every secondary student should be able to write a simple program; over 43 percent of the teachers disagreed with that idea. Mathematics and science teachers revealed the uses to which they put computers, and the uses falling under the umbrella of computer literacy were limited. The authors concluded that while science and mathematics teachers agreed that students need a minimal knowledge of computers, computer topics were not being adequately covered in their classes.

Becker, Henry Jay. "Our National Report Card: Preliminary Results from the New Johns Hopkins Survey." Classroom Computer Learning 6 January 1986: 30-33.

This is the second general purpose computer survey conducted by Becker; his first was in 1983. He reported that of all educational personnel, the most active computer users were classroom teachers. Of the computer using teachers (including junior high and high school teachers), the highest percent of computer users were mathematics teachers, followed by computer specialists. In the secondary schools, the majority of the teachers felt that programming and computer literacy were the most important uses of the computer. In general, males used the computers more often than females. Computer crime was a small problem overall. The top problem was not enough resources such as the computers themselves, not enough software, and not enough money for teacher training. The largest group of respondents wanted the computers to be located together in an independent computer lab.

Sherzer, Bill. "Where Are the Computers?" Computing Teacher 6 (1979): 6-9.

This informal study dealt with certain aspects of using computers in a school district in Oregon. The author looked at the number of computer terminals in the school district as well as teacher instructional time relating to computers and concluded that present classroom computer use in this school district was modest. By observing students at work at their terminals, Sherzer noted that only about 50 to 75 percent were able to log on to the computer. The students who were able to log on demonstrated nearly 100 percent on-task behavior. The implication is that students may need orientation in order to be more receptive to computer usage. In all of the four high schools in the district, the mathematics department ran the show as far as computers were concerned. Teacher use of the computer as a part of their instruction was low, and the main reason given for this deficiency was that there was not enough time. Two school administrators were interviewed, and both men liked the idea of using computers in the curriculum, but felt that money was a limiting factor.

Course content and programmer characteristics

Buchman, Aaron L., and Frank S. Hawthorne. "The Content of High School Computer Mathematics Courses." School Science and Mathematics 75 (1975): 543-49.

The author attempted to clarify what was being taught in high school computer mathematics classes. A questionnaire was sent to all computer mathematics teachers in the state of New York. The authors compiled four tables describing various topics taught in computer mathematics, and the most important table presented a list of eighteen topics taught in at least 60 percent of the schools. The authors also sought to find out whether or not there was a significant relationship between the number of years a teacher taught computer mathematics and what content that teacher considered important. The findings indicated that a teacher's experience factor had little effect on the ranking of topics. Although content taught varied somewhat depending on what computer hardware was used, the most important result of the survey was that computer mathematics teachers teach quite a bit of the same content in their courses.

Widmer, Connie C., and Janet Parker. "A Study of Characteristics of Student Programmers." Educational Technology 25 (1985): 47-50.

The authors surveyed participants from an international programming contest. The participants ranged from fourth through twelth grades. It was found that the number of male participants (248) far outweighed the number of female participants (28). 41 percent of the males had been programming for more than two years, whereas only seven percent of the females had been programming that long. BASIC was the programming language most widely used as 97 percent of the participants reported using it. Computer use was promoted by easy access to computers: 79 percent of the contestants had access to the school's computers after school, and 77 percent had a computer at home. Most of the participants were also good mathematics students as 90 percent of them estimated their mathematics grade to be A or B. Students who performed well in the programming contest generally shared the two characteristics of having had a programming class and having a home computer.

The effect of computers upon various attitudes

General

Marshall, Jon C., and Susan H. Bannon. "Computer Attitudes and Knowledge in Rural Settings." Research in Rural Education 2 (1985): 155-58.

The authors reported on computer attitudes, knowledge, and access for students and educators in rural settings. The sample consisted of 198 students in grades nine through twelve and 43 educators from kindergarten through twelth grade and administrators. Both groups demonstrated positive attitudes toward computers in education. The educators demonstrated a higher level of computer knowledge than did the students, and the males demonstrated greater knowledge than the females. As a group, the male students were more computer literate than the female educators. All of the students said they had some school access to computers, and about 38 percent said they had home access. The most common computer at school was an Apple and at home was an Atari. 77 percent of the teachers felt that the computer had been an institutional improvement, but only 60 percent of the administrators felt the same way.

Lloyd, Brenda H., and Clarice Gressard. "The Effects of Sex, Age, and Computer Experience on Computer Attitudes." Association for Educational Data Systems Journal 40, (1984): 67-77.

The authors studied the effects of sex, age, and computer experience on the computer attitudes of computer anxiety, confidence, and liking. The subjects were high school, community college, and senior college students. In general, the students had positive attitudes toward computers. Computer experience was found to have a significant effect upon computer attitudes, with more experience linked with lower anxiety, higher confidence, and higher computer liking. Age was only significant for computer liking. Among the most experienced computer users, students 13 to 15 years old liked computers more than students 21 years old or older. Finally, the data indicate no differences between the sexes in any of the three computer attitudes.

Saunders, James, and Frederick H. Bell. "Computer-Enhanced Algebra Resources: Their Effects on Achievement and Attitudes." International Journal of Mathematical Education in Science and Technology 11 (1980): 465-73.

The experimenters used students in four algebra-two classes as the subjects. Two classes comprised the control group which received no special treatment. The other two classes were required to do computer work in addition to the normal classroom load. Saunders and Bell wanted to find out if computer-enhanced resource materials could be used in the algebra classes without having a negative effect on the students' achievement and attitudes. They also wanted to determine whether or not this additional computer use could be accomplished without taking time from the normal algebra content. The authors found that the use of the computer materials had no significant effect upon algebra achievement, upon the students' attitudes toward mathematics, and upon the instructional setting (classroom). A significant difference (improvement) was found in the experimental students' attitudes toward the computer from the middle of the school year to the end. The authors concluded that students can learn how to use a computer while taking a second year algebra course without significantly affecting achievement levels, and with no harmful effects on their attitudes toward mathematics and the instructional setting.

Robitaille, David F., James M. Sherrill, and David M. Kaufman. "The Effect of Computer Utilization on the Achievement and Attitudes of Ninth-Grade Mathematics Students." Journal for Research in Mathematics Education 9 (1977): 26-32.

These authors conducted a study involving ninth-grade algebra students in order to determine the effect of computer utilization on student achievement and attitudes toward secondary school mathematics. Three ninth-grade algebra classes in two different schools were used, with each school having a class use computers often, a class use computers occasionally, and a class never use computers. The study at school A ranged from September to December, and the study at school B ranged from September to May. At the end of the evaluation period in school A, the computer group had the most positive attitude toward mathematics, but had the lowest mathematics achievement scores. In school B, the no-computer group had the highest mathematics achievement scores. The author felt that this may have been due to using a different teacher for that group than for the other two groups. Also in school B, no significant difference was found in attitude toward mathematics. The results of these studies generally do not support the claims made by proponents of computer-augmented instruction.

DeBlassio, John K., and Frederick H. Bell. "Attitudes Toward Computers in High School Mathematics Courses (1)." International Journal of Mathematical Education in Science and Technology 12 (1981): 47-56.

The authors studied 220 students in selected mathematics courses in a high school in Pennsylvania. They found statistically significant positive relationships between student attitudes toward using a computer in mathematics classes and their attitudes toward mathematics, achievement in programming, attitudes toward the instructional setting, achievement in mathematics, and previous experience in programming. There was no significant relationship between student attitudes toward using a computer and their intelligence. There also was no significant difference between the attitudes of boys and girls toward using a computer in mathematics class. Research into the personalities of those who liked using the computer revealed that they were above average in intelligence, amount of vigor, liking to solve problems involving original thinking, mathematics, and programming. Those who disliked computers tended to be average in mathematics, programming, and amount of vigor; they also tended to be more responsible, cautious, and anxious. Finally, students liked using a computer because it was a different activity from regular class. It was also emphasized that the students needed to have favorable experiences early in learning to use the computer.

The effect of computers upon mathematical achievement

Junior high

Hatfield, Larry Lee. "Computer-Assisted Mathematics: An Investigation of the Effectiveness of the Computer Used as a Tool to Learn Mathematics." (University of Minnesota, 1969), Dissertation Abstracts International, 1970, 30, 4329-A to 4330-A.

The author studied the effects of computer programming on a seventh-grade mathematics course. The study covered two years and each year was considered a separate experiment. The control group learned mathematics without the use of the computer, and the experimental group studied the same mathematics but were also required to learn the computer. The subjects were also placed into low, middle, and high previous achievement groups. Test items were classified as "skill", "concept", or "problem" items. During the first year, the effect due to treatment was significant on only one of the eleven criterion tests, favoring the non-computer treatment. The author felt that the reason for this was that the computer students were studying BASIC programming while studying the mathematics for that criterion, and this detracted from their study of the mathematics. On 226 individual items, the control group scored significantly better on 22 items and the computer group scored significantly better on 19 items. On eight significant "skill" items, the control group was favored. During the second year, the computer group scored significantly higher on three out of 12 tests with middle and high achievement computer groups favored. On 327 individual items, the computer group scored significantly better on 25 items, while the control group scored significantly higher on 13 items. The computer group scored significantly higher on 12 of the 16 "problem" items and 10 of the 16 "concept" items.

Hearne, J. Dixon, and Jim Lasley. "The Relationship Between Achievement Factors and Gender Specific Computer Aptitude Among Junior High School Students." Education 106 (1985): 81-87.

The authors examined the relationship between mathematical and verbal skills and computer aptitude. The subjects were 124 male and 129 female junior high school students. The results of the study indicated that for both males and females, the strongest predictor of computer aptitude was conceptual ability (mathematics concepts). The second most powerful predictor of computer aptitude for males and females was mathematics application skills. Another finding was that the same independent variables (mathematics conceptual ability, mathematics application skills, language ability, and reading comprehension) contributed almost the same amount to computer aptitude in male and female subjects. A different finding was that none of the traditional scholastic aptitude measures (independent variables) contributed a large amount to computer aptitude (28 percent at best).

High school

Ronan, Franklin Delano. "A Study of the Effectiveness of a Computer When Used As a Teaching and Learning Tool in High School Mathematics." (The University of Michigan, 1971), Dissertation Abstracts International, 1971, 32, 1264-A to 1265-A.

The author conducted an experiment to determine whether or not students of the same ability level who use a computer to learn mathematics attain a higher level of achievement than those who do not use a computer. He divided the algebra-trigonometry students into two groups which studied the same mathematics, but the experimental group used a computer and the control group did not. He found no significant differences between the two groups for the review of algebra and radicals in equations, trigonometric functions and complex numbers, and circular functions and their inverses. Computer users achieved more after the study of exponential functions and logarithms. Non-computer users achieved more after the study of trigonometric identities and formulas. Both computer users and non-computer users showed significant growth in understanding mathematical concepts and ability to perform mathematical problem solving, but the computer users also showed significant growth in development of mathematical skills, whereas non-computer users did not. There was no significant difference between the two groups in ability to apply mathematical concepts. There was no significant difference in problem solving between the two groups. Finally, computer users attained a higher level of logic and reasoning ability than non-computer users.

Kieren, Thomas Ervin. "The Computer As a Teaching Aid for Eleventh Grade Mathematics: A Comparison Study." (University of Minnesota, 1968), Dissertation Abstracts International, 1969, 29, 3526-A to 3527-A.

Kieren investigated the effects of computer programming on the achievement level in mathematics of high school students. The subjects were divided into two groups. The control group learned eleventh-grade mathematics by conventional teaching, and the experimental group was required to write computer programs. Kieren found significant differences favoring the computer treatment on an advanced algebra test and on a quadratic functions test. He also found a significant difference favoring the regular treatment on a trigonometry test. Viewing students as high or average based upon previous mathematics achievement, the computer had a stronger effect upon the achievement of the average achieving students than upon the high achieving students. The author also stated that the computer treatment appeared to contribute most to the learning of complex processes, organization and relation of data, and infinite processes. Finally, the computer classes appeared to be comparatively deficient in trigonometric and geometric concepts.

Hoffman, Irwin J. "Effects of Computer Application on Generalization Skills and Achievement in a Second Year Algebra Course." (University of Denver, 1971), Dissertation Abstracts International, 1971, 32, 2856-B to 2857-B.

The author studied the effect of computer utilization in a second year algebra class upon generalization skills and achievement. The study took place in two high schools, with a different teacher teaching one class not using computers and one class which wrote BASIC programs. Hoffman found no evidence that computer extended instruction significantly affected generalization skills or achievement levels. However, an item analysis revealed that the computer treated classes were more successful in simple generalization skills which related to a process of analysis which substitutes ideas from a multiple choice response into the questions. This process is similar to debugging a program. Finally, students classified in a high previous knowledge category learned more about multiplying a function by a constant with computer application, and students classified in a low previous knowledge category learned more about multiplying a function by a constant without the computer application.

Katz, Saul M. "A Comparison of the Effects of Two Computer Augmented Methods of Instruction with Traditional Methods Upon Achievement of Algebra Two Students In a Comprehensive High School." (Temple University, 1971), Dissertation Abstracts International, 1971, 32, 1188-A to 1189-A.

The author studied the effects of supplementing the traditional algebra two curriculum with computer program writing. The algebra two students were placed into three groups. The control group was not required to use the computer; the experimental one group wrote their own programs, but someone else ran them; and the experimental two group wrote and ran their own programs. The results showed that the experimental two group scored significantly lower (at the five percent level) than the other two groups. Katz hypothesized that the reason for this was that computer room time took away from classroom instructional time. Katz concluded that the most effective use of the computer would be tc require computer program writing without access to the computer as opposed to writing computer programs with access to the computer.

Bell, Frederick Harold. "A Study of the Effectiveness of a Computer-Oriented Approach to Calculus." (Cornell University, 1970), Dissertation Abstracts International, 1970, 31, 1096-A.

Bell studied the effects of using a computer in the study of calculus. He set up a control group which studied calculus and wrote non-calculus computer programs, and an experimental group which studied the same calculus but wrote calculus oriented computer programs. He tested for understanding of techniques and concepts of calculus immediately after instruction and one month later. He found no difference between experimental and control groups in ability to exhibit techniques of calculus immediately after instruction and one month later. He did find significant differences between the two groups in understanding calculus concepts both immediately after instruction and one month later, in favor of the experimental group.

Gender differences

Effect on attitudes and achievement

Wilder, Gita, Diane Mackie, and Joel Cooper. "Gender and Computers: Two Surveys of Computer-Related Attitudes." Sex Roles 13 (1985): 215-228.

The authors presented the results of two separate surveys on computer attitudes. The first study surveyed students in grades kindergarten through 12, and the second study surveyed college freshman. This abstract only presents results of the first study which are relevant to the present paper. The subjects of the first study were more than 1600 students in grades kindergarten through 12 in a New Jersey school district. With regard to sex typing of computers, it was found that boys and girls alike perceived the computer as being more appropriate for males; and on a statistically significant level, boys more so than girls perceived the computer as being more appropriate for males. The sex-typing increased with age, although at all levels the girls saw the computer as being less masculine than did the boys. As for attitudes, the boys liked the computer more than did the girls at all age levels. The authors reported a steady decline in liking for the computer over time by both sexes.

Collis, Betty. "Sex-related Differences in Attitudes Toward Computers: Implications for Counselors." The School Counselor 33 (1985): 120-30.

After citing several sources which indicated that women are not as interested as men in computers, the author studied this problem in the context of sex-role socialization, poor self-efficacy of women, and negative attitudes held by women toward the computer. A 42 item computer survey was administered to 1818 male and female students, and interviews were also conducted. The study revealed that when asked who in the household was most likely to use a computer, men or boys were the most common answer. For female self-efficacy, the typical girl believed that women in general could use a computer, but that she as an individual was not competent. Finally, women tended to have a negative attitude toward computer users, and were less positive than boys in their attitudes toward the computer.

Hess, Robert D., and Irene T. Miura. "Gender Differences in Enrollment in Computer Classes and Camps." Sex Roles 13 (1985): 193-203.

The authors studied the enrollment in computer camps and classes as a way to detect interest in computers because the enrollment would be on a voluntary basis. The authors studied camps from around the nation, used a questionnaire to gather data, and categorized the participants into three grade levels including kindergarten through fourth-grade, fifth- through eighth-grade, and ninth- through twelth-grade. The overall enrollment consisted of 73.8 percent boys and 26.2 percent girls. The percent of girls enrolled declined with increasing grade level, ranging from 30 percent in the primary grades, to 26 percent in the middle school grades, to 24 percent in high school. In general, as the computer course became more difficult, there was a decline in female enrollment. Also, as the cost of the camp increased, so did the male enrollment. The authors hypothesized that the enrollment figures could be due to the similar trend in mathematics, the stereotype of computers being controlled by males, male oriented software titles, more encouragement of males by parents, and sex differences in spatial abilities possibly related to programming.

Literacy and perception of societal influences

Fetler, Mark. "Sex Differences on the California Assessment of Computer Literacy." Sex Roles 13 (1985): 181-91.

The author studied the knowledge, attitudes, and experiences of California sixth- and twelth-grade boys and girls in the area of computer technology. 17,861 twelth-grade students participated in the study. Among the twelth-grade students, boys outperformed girls in all nine areas of computer literacy and achievement, reaching statistical significance in eight of the nine areas. In the category of attitudes toward computers, boys and girls differed statistically on two statements: girls felt that computers were more likely to slow down and complicate business operations, and boys were more likely to feel that computers help make mathematics more interesting. It was also found that girls have less experience with computers than boys, and this might have been due to girls having or taking fewer opportunities to work with and learn about computers both at home and at school.

Kwan, Stephen K., Eileen M. Trauth, and Kathleen C. Driehaus. "Gender Differences and Computing: Students' Assessment of Societal Influences." Education and Computing 1 (1985): 187-94.

The authors investigated student attitudes toward societal factors involving computer use and the extent to which the students acknowledged the influence of societal factors. The subjects of the study were generally college bound students enrolled in mathematics classes. The instrument used was a Likert-style questionnaire and the questions could be broken down into four general categories: computing as a male domain, influence of significant others, negative attitudes associated with computers, and career aspirations. The students only agreed with the societal factor of computing as a male activity, and this was only an agreement that the media portrayed computing as such. Concerning the societal factor of career aspirations, the subjects consistently agreed on the positive relationship between being competent with computers and being successful in college, becoming employed, and being promoted. In general, the females tended to have stronger opinions on the issues than the males, especially with regard to specific statements on female interest, ability, and behavior. This study showed that students (especially females) are rejecting society's stereotypes with regard to gender differences and computing.

SUMMARY

In looking at the way in which computers are used in secondary education, we can see that when programming is taught, BASIC is the most commonly used language (Widmer and Parker 49, Readers' Survey Results...." 53). Of all educational personnel, the most active computer users are classroom teachers, and mathematics teachers seem to be heavily involved (Becker 31, Sherzer 7). One factor which is a possible deterrant for abundant computer resources is money (Becker 33, Sherzer 8).

As computers begin to proliferate in the schools, the problem of what to teach must be addressed. In a 1978 survey of Minnesota educators, secondary science and mathematics teachers agreed that every student should have a minimal understanding of computers, and most agreed that students should learn about the role that computers play in society (Hansen et al. 468). When computer mathematics teachers in New York state were asked about course content, there was general agreement as eighteen topics were taught in at least 60 percent of the schools (Buchman and Hawthorne 545). It was found that the amount of experience a teacher has had little effect upon what topics were taught in computer mathematics (Buchman and Hawthorne 548). It should be noted that some teachers were not putting forth much effort to incorporate the computer into their lesson plans (Sherzer 6, Hansen et al. 472).

Several researchers have studied the effect of the computer upon various variables. It has been found that many students have a positive attitude toward the computer itself (Saunders and Bell 470, Marshall and Bannon 156, Lloyd and Gressard 76). Researchers have also found that computers can develop in students a positive attitude toward mathematics

(Robitaille, Sherrill, and Kaufman 30, DeBlassio and Bell 53). DeBlassio and Bell also found a statistically significant positive relationship between student attitudes toward using a computer in mathematics class and their attitudes toward the instructional setting (53). Lloyd and Gressard found that computer experience has a positive effect (statistically significant) on student attitudes resulting in lower anxiety, higher confidence, and higher computer liking (76). While Hess and Miura found a decrease in interest among females as they grew older (197), Lloyd and Gressard found no clear pattern of computer liking among the general student population with respect to age (76).

Many researchers have studied the effect of computer programming upon mathematics achievement. Most such studies compared a no-computer mathematics class (control group) with a computer augmented mathematics class (experimental group). Results of the effect of the computer upon mathematical achievement have been mixed. Hatfield studied computers and seventh-grade mathematics, and during his first experiment, the non-computer group and the computer group achieved at approximately the same level, with a slight edge to the non-computer group (4329-A). During his second experiment, the computer group had a higher level of mathematics achievement (4330-A).

Hearne and Lasley also studied the computer and junior high students and found that for both male and female subjects, the strongest predictor of computer aptitude was mathematics conceptual ability, followed by mathematics application skills (83). The authors also found that mathematics conceptual ability, mathematics application skills, language ability, and reading comprehension contributed in nearly the same

proportion to computer aptitude in both males and females (85). Hearne and Lasley also found that none of the four variables mentioned above contributed a large amount (28 percent at best) to computer aptitude (85).

Mathematical achievement as a result of computer programming appears to be topical. Ronan found that computer users achieved more than non-computer users when the mathematics topic studied was exponential functions and logarithms (1264-A). The computer users achieved more in the development of mathematical skills, and attained a higher level of logic and reasoning ability than did non-computer users (Ronan 1264-A). The non-computer users, however, achieved more after studying trigonometric identities and formulas (Ronan 1264-A). Kieren also found topical mathematics achievement as a result of computer programming. Kieren found significant achievement with a computer group over a non-computer group with the study of advanced algebra and quadratic functions (3526-A). Kieren also found significant achievement favoring the non-computer group in trigonometry (3526-A), which agrees with Ronan. Kieren further noticed that the computer group was deficient in trigonometric and geometric concepts (3527-A). In general, Kieren felt that the computer helped average achieving students more than high achieving students (3527-A), and that the computer helped all students most in the learning of complex processes, organization and relation of data, and infinite processes (3527-A).

Hoffman looked at the effect of computer use upon generalization skills and achievement. He found that computer use did not significantly affect generalization skills or achievement levels (2857-B). He did find, however, that the computer group was more successful in simple

generalization skills which related to a process of analysis similar to debugging a computer program (2857-B).

Katz studied the effect of computer augmented learning upon mathematics achievement by dividing his subjects into three groups: one group wrote no computer programs; one group wrote programs but other people ran them; and one group wrote programs and ran them themselves. After seeing that the group which wrote and ran their own programs scored significantly lower than the other two groups on an algebra two achievement test, Katz felt that the most productive method of instruction would be to require the students to write computer programs but to have someone else run them (1189-A).

Bell studied the effect of the computer upon learning calculus. He found no significant difference between the non-calculus computer program writers and the calculus computer program writers in ability to exhibit techniques of calculus (1096-A). He did find that the calculus computer programming group did significantly better in understanding calculus concepts than did the non-calculus computer program writers (1096-A).

Several researchers have studied sex-related differences with regard to computer technology. Many of these researchers have found that boys generally are more interested in computers than girls (Collis 128, Wilder, Mackie, and Cooper 218, Hess and Miura 196, Becker 32, Widmer and Parker 48). Some researchers, however, have found no significant differences between male and female attitudes toward the computer (Kwan, Trauth, and Driehaus 189, DeBlassio and Bell 53, Lloyd and Gressard 76). Some researchers have found that boys achieve more in computer programming than girls as evidenced by the following cases.

In California, twelth-grade boys outperformed twelth-grade girls in all nine areas of computer literacy and achievement, reaching statistical significance in eight of the nine areas (Fetler 184). Hess and Miura reported that as the computer curriculum became more difficult, fewer girls enrolled in computer camp and summer classes (197). Marshall and Bannon found that in rural settings, males demonstrated greater computer knowledge than females (157). Widmer and Parker, however, reported no significant difference along sex lines in programming achievement among student programming contestants in their analysis of an international programming contest (48).

CONCLUSIONS

Computer programming in education is mainly done using the BASIC programming language (Widmer and Parker 49), and mathematics teachers are usually involved to some extent with computers (Becker 31, Sherzer 7). Computer mathematics teachers teach many of the same topics in their classroom instruction (Buchman and Hawthorne 545), but many teachers are not incorporating the computer into their lesson plans (Sherzer 6, Hansen et al. 472).

In general, students have a positive attitude toward the computer itself (Saunders and Bell 470, Marshall and Bannon 156, Lloyd and Gressard 76). In some cases the computer can motivate the learning of mathematics (Robitaille, Sherrill and Kaufman 30, DeBlassio and Bell 53). The data were mixed on the question of whether interest in the computer increased or decreased with age (Hess and Miura 197, Lloyd and Gressard 176).

Programming and mathematics seem intricately related, as Hearne and Lasley found that the two best predictors of programming are mathematics conceptual ability followed by mathematics application skills (83). The amount that computer programming contributes to achievement in mathematics appears to depend on the topic studied. Ronan found significant achievement for computer users for the study of exponential functions and logarithms, for the development of mathematical skills, and for the attainment of higher levels of logic and reasoning ability (1264-A). Kieren found significant achievement for the computer users with advanced algebra and quadratic functions (3526-A). Ronan found that the non-computer users achieved more with trigonometric identities and formulas (1264-A), and Kieren found better achievement

for the non-computer group in trigonometry (3526-A). Hoffman found no significant difference between computer users and non-computer users for generalization skills and achievement (2857-B). Katz felt that the most productive instructional setting would be for the students to write but have someone else run their mathematical programming applications (1189-A). Bell found that writing calculus computer programs helped the students better understand calculus concepts. (1096-A).

Boys tend to be more interested in and have better attitudes toward computers than girls (Collis 128, Wilder, Mackie, and Cooper 218, Hess and Miura 196, Becker 32, Widmer and Parker 48). Boys also seem to achieve more than girls in computer programming skills (Fetler 184, Hess and Miura 197, Marshall and Bannon 157).

RECOMMENDATIONS

1. Keep programming instruction closely associated with the teaching of mathematics.

2. Use the computer in a traditional mathematics class as a tool to motivate the students.

3. Require the advanced mathematics classes to write computer programs occasionally to augment mathematics instruction.

4. Avoid reinforcing any societal sterotype about computers being a male domain.

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IV. Employment experience

A. Substitute teacher 1984-1985
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V. Reasons for interest in topic

I am interested in this topic because I teach secondary mathematics and computer programming. This study allows me to review research on problems and issues which could be useful in my daily work.